TECHNICAL PROPOSAL

Title: Straw Management and Crop Rotation Alternatives to Burning Wheat Stubble

Principal Investigator: R. James Cook, Department of Plant Pathology, Washington State University.

Co-Principal Investigators: David Huggins, Soil Scientist, and Timothy Paulitz, Plant Pathologist, U.S. Department of Agriculture, Agricultural Research Service, Pullman, WA.

Collaborator: William Schillinger, Dryland Research Agronomist, Washington State University

A. Project Approach/Methodology

This project will be carried out on the 140-A Washington State University (WSU) Cunningham Agronomy Farm (CAF), located about 7 miles NE of Pullman. A complementary study will be carried out at the WSU Experiment Station near Lind, as an expansion of an ongoing study of alternatives to burning stubble of irrigated winter wheat. Unless stated otherwise, all work will use direct seeding (no-till) farming methods, defined as "systems that plant and fertilize directly into undisturbed soil, as one pass, and those that fertilize first and then plant, as two passes." This definition of direct seeding has been adopted by the Pacific Northwest Direct Seed Association (PNDSA), which has its stated goal to have 2 million acres of PNW cropland under direct seed systems by 2005.

The work on the CAF (three projects, CAF No. 1, 2 and 3) will be part of a large, on-going, multidisciplinary, direct-seed and precision agriculture cropping systems project using commercial scale farming equipment under dryland conditions but with high yields of straw, typical of the Palouse region. The work on the WSU station at Lind (one project) will be part of a research effort, now starting the 2nd year, to find economic alternatives to burn/moldboard plow currently used in some low-precipitation areas of eastern Washington to maintain yields of continuous (monoculture) winter wheat irrigated from deep wells.

The four proposed projects are:

- Cunningham Agronomy Farm Project No. 1—Spring wheat Straw Management for Production of Winter Wheat Without Burning.
- Cunningham Agronomy Farm Project No. 2—Winter Wheat Straw Management for Production of Alternative Crops Without Burning.

- Cunningham Agronomy Farm Project No. 3—Crop Rotations as Alternatives to Burning for Root Disease Management on Wheat.

- Lind Research Station Project—Documentation of Wheat Straw Management and Rotation Alternatives to on Root Pathogen Populations Under Irrigation.

Cunningham Agronomy Farm Project No. 1—Spring wheat Straw Management for Production of Winter Wheat Without Burning.

The CAF represents a typical Palouse landscape, with steep hills and deep, highly erodible soils. Leaving the crop residue undisturbed on the soil surface, typical of direct-seed systems, provides the best protection against water runoff and soil erosion. In addition to less sediment moved into area ditches, streams and rivers, less runoff translates into higher yield potential since more of the precipitation and snow-melt water is now captured and stored in the soil profile for growth of the next crop rather than allowed to leave the field. Direct seeding is the only practice that currently qualifies for compensation under terms of the contract between the PNDSA and Entergy of New Orleans for sequestered carbon as an offset to this energy company's carbon dioxide emissions at their coal-fired energy-generating plants. Unfortunately, the large amounts of straw produced by a typical healthy wheat crop makes direct seeding an enormous challenge. Plugged drills, "hairpinning" of straw into the seed furrow, and straw clumping behind the drill and on top of the newly planted crop are among the challenges that cause growers to burn.

This phase of our work (Fig 1.) will compare the effectiveness of three straw management alternatives to a no-treatment control as a means to solve the straw problem without burning.

1. Following the lead of the Horsch system in SE Germany (Bavaria region), where the climate, cropping systems, and high-straw yields match Palouse conditions and circumstances, the wheat crop will be harvested with a) stubble cut short by keeping the header only 3-4 inches above the soil surface and b) maintaining razor-sharp blades in the straw chopper so as to consistently reduce the straw to 4- to 5-inch lengths as it drops onto the spreader designed to spread straw and chaff the full-width of the header.

2. Stubble will be cut at a normal 12- to 15-inch height and the straw chopped into short lengths with full header-width spreading, to be followed within a few days after harvest with a Combs heavy harrow and cutter bar to further shorten the stubble to 6- to 8-inches and further spread and fragment the straw on the soil surface.

3. As 2, but heavy harrow only, without the cutter bar.

4. Stubble cut at normal height and cut into short length for full header-width spreading, but thereafter left undisturbed and the sites planted and fertilized directly (control).

Field Layout and Rotations—2000/2001 Crop Year

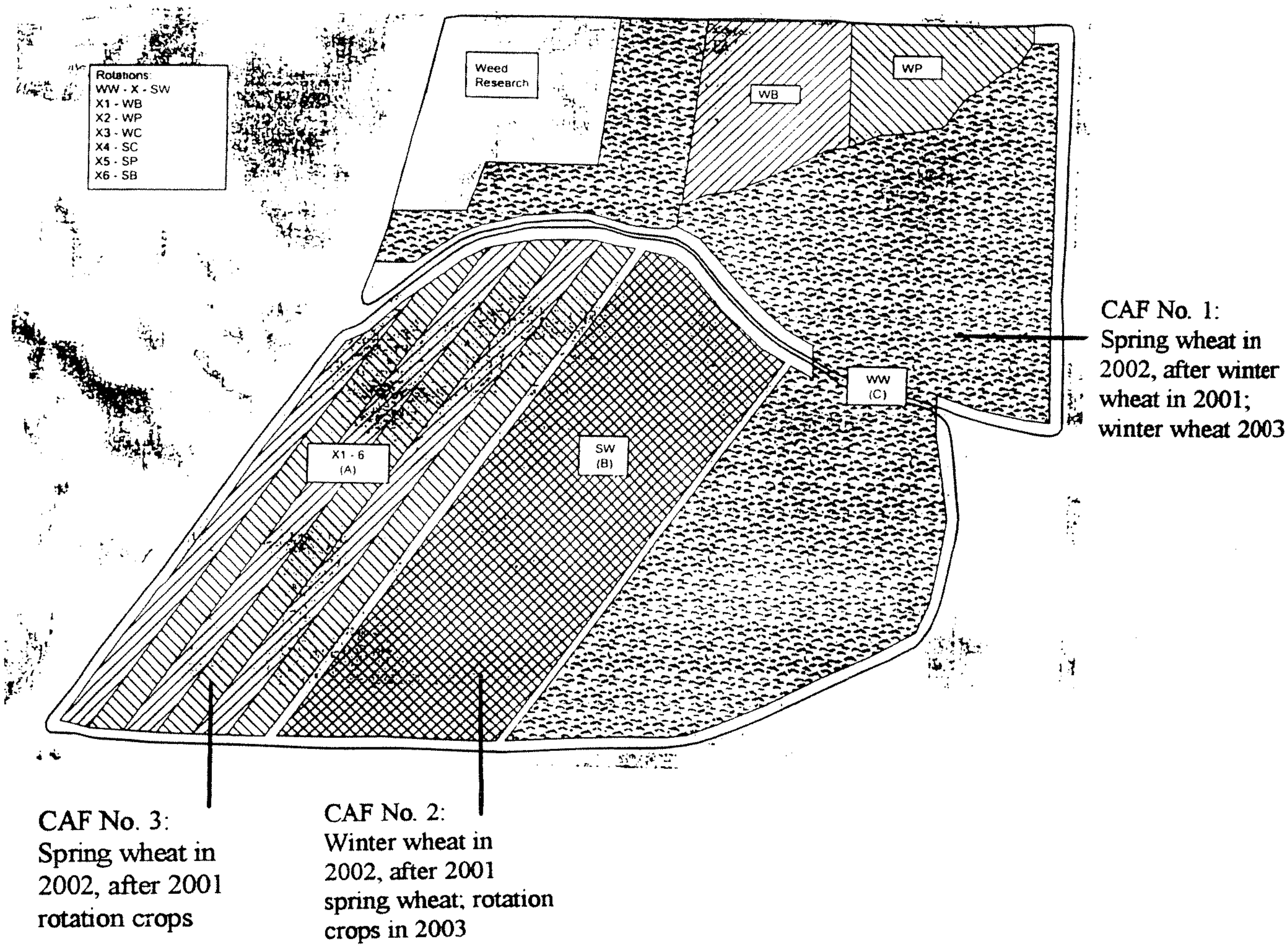


Fig 1. Map of the Washington State University Cunningham Agronomy Farm, located about 7 miles NE of Pullman. The farm is 140 acres in size and has been in continuous cropping with direct seeding (no-till) with no stubble burning since 1999. The entire farm has been mapped in detail by elevation, aspect, and soil type and is devoted to long-term direct seed cropping systems and precision agriculture research.

Each of these four straw management treatments will be replicated at least three times—four time if possible with available space and topgraphy. In addition, within each straw management strip, proposed at 60 feet in width and variable but roughly 400 feet in length or longer, we will establish four small (16' x 24') plots of: a) no further treatment (control); b) straw residue burned; c) straw and soil fumigated with methyl bromide under plastic tarp; and d) straw burned and soil then fumigated under a plastic tarp (see Attachment A for examples of similar studies done previously using this approach). These same plots within one of the reps will be used to monitor soil temperature and moisture in the seed zone (approximately 1.5 inches deep) in response to the different straw management treatments from the time of planting through seedling emergence or later, depending on the fall.

Each of the three straw management alternatives to current practice has advantages and disadvantages. Cutting the stubble short slows the harvesting operation since more straw must pass through the combine. On the other hand, this method potentially eliminates the need for a heavy harrow with or without the cutter bar. This method also reduces cover for mice and voles that can become serious pests of direct-seeded crops and for which a method of control is still to be developed. Use of a heavy harrow is another operation with additional wheel- traffic and potential for soil compaction, and it requires ownership and maintenance of another piece of equipment. The cutter bar adds still more investment and maintenance expenses, but would allow faster harvest. However, this treatment must follow immediately after harvest, while the stubble and straw are still dry and brittle, and might need to begin before all harvest on the ranch is completed. On the other hand, the reduction in straw load on the soil surface with a heavy harrow not only makes it easier to direct seed winter wheat in the fall, the soil with less residue can be expected to warm faster in the spring, which can help to accelerate growth and development of the winter wheat as it comes out of its dormancy (observed on the Cunningham Agronomy Farm in the spring of 2002, for winter wheat planted into 2001 spring wheat stubble following a heavy harrow treatment).

Planting winter wheat into any cereal stubble without an intervening fallow or broadleaf crop presents one of the greatest challenges for direct seeding. This is because the 2 months between harvest (August) and planting winter wheat (October) is too short and conditions are too dry for even the earliest stages of straw decomposition. By comparison, 8-months between harvest (August) and planting spring wheat (April) is enough time and conditions usually are suitable for considerable weathering and some decomposition before planting, depending on over-winter temperatures. Even the earliest stages of decomposition and resultant fragile nature of the straw can make it easier to plant into the residue in the spring with or without harrowing in the fall.

The disadvantages encountered when planting in the fall into fresh straw can be partially offset by planting winter wheat after spring wheat, since spring wheat produces less straw than winter wheat. Growers in the Palouse region expect to plant at least half of their land in the fall and half in the spring, to spread their work load more evenly between fall and spring. In addition, direct-seeders commonly prefer more fall- than spring seeding since land in the spring can be soft and more prone to wheel tracks and compaction.

Owing to the exceptional moisture supplies, virtually all of which entered the soil during the winter of 2002/2002, the 2002 spring wheat crop intended to produce stubble for this study was fertilized for yield goal of 75 bu/A averaged over the site. This means that, owing to the within-field variability over the landscape, some georeferenced sites will produce more than 90 bu/A and others less than 60 bu/A. This should result in straw yields of 5-6,000 lbs. per A in areas with the highest yields and 3-4,000 lbs./A in areas with the lowest yields. Our method of monitoring stand establishment and crop growth and yield based on intensive sampling over the landscape based on georeferenced sites using GPS will take this variability into account. This approach allows us to test our straw management treatments within both high and modest or low straw loads, all within the same field.

Cunningham Agronomy Farm Project No. 2—Winter Wheat Straw Management for Production of Alternative Crops Without Burning.

This project will be a scaled-back version of CAF No.1 with straw management treatments and a burn treatment, all established as small (16' x 24') replicated plots of 2002 winter wheat stubble before planting alternative winter crops in a 3-year winter wheat/alternative crop/spring wheat rotation (see Fig 1). The rotation project is already underway, having been started in the fall of 2000 on the major portion of the CAF (92 acres). Before this, extensive base data were obtained from the site during 1999 and 2000, including historic maps of grain yields and protein of crops grown in 1999 and 2000, maps of weeds, including wild oats, the distribution of a root disease caused by *R. oryzae,* and detailed maps of soil types and rooting depths to the Argillic clay horizon. Each map is based on 369 georeferenced sites using GPS on a nonaligned grid. Probably no equivalent area of farmland in the PNW has been sampled and mapped any more intensively.

Six WW/Alt/SW rotations were started in the fall of 2000 by dividing the 92-A field into three fields of about 30 acres each, and then planting one to winter wheat, dividing one into 4-6 A strips for six alternative crops, and planting the third uniformly to spring wheat in the spring of 2001 (Fig 1). Three of the six alternative crops, namely winter barley, winter Canola and winter peas, were planted in the fall of 2000, and three spring crops (spring barley, spring pea, and spring Canola) were planted in the spring of 2001. Starting in the fall of 2001, the 30-A field of spring wheat was direct seeded to winter wheat following a heavy harrow treatment of the stubble, and the three alternative winter crops were direct seeded into the 2001 winter wheat stubble. In the spring of 2002, spring wheat was direct seeded uniformly over the six 4-6 A strip following the alternative crops, and the three spring alternative crops were direct seeded into the remaining three 5-A strips in the 2001 winter wheat stubble. This cycle will be repeated in the 2002-2003 crop year, always planting winter wheat into spring wheat stubble, alternative fall- and spring-sown crops into winter wheat stubble, and spring wheat after the six alternative crops. Weed control, fertilization, and rates and dates of seeding are adjusted as necessary for best management practices within each rotation. All assessments, including grain yield and protein, pest pressures, available water and nitrogen, and economic analyses will be spatially analyzed using GIS and geostatistical approaches to assess landscape patterns of agronomic performance and to evaluate major causal factors contributing to rotation effects as part of a federally funded project (Solutions to Economic and Environmental Problems; STEEP, starting in October, 2002).

As part of the DOE-funded portion of this project, we propose to establish our straw management and burn treatments in the 2002 winter wheat stubble prior to planting the three fall-sown alternate crops (winter barley, winter Canola, and winter peas). This is intended to further address the challenge of direct seeding in the fall when the stubble is still fresh. Three differences between this experiment and CAF No. 1 will be a) the stubble will be winter wheat rather than spring wheat, creating the greater challenge because of the higher straw load and the fact that the straw is fresh, b) alternative fall-sown crops rather than winter wheat will be seeded into this stubble, and c) the treatments will be established with hand or power tools rather than commercial-scale equipment, owing to the small area available for the plots within the respective 5-A strips of CAF No. 2.

Starting with winter wheat stubble at normal height, and straw chopped short and spread the full width of the combine header, the straw management treatments established will be:

1. Stubble trimmed to 5-6 inches with a Jari mower and the residue spread with hand raking to simulate the heavy harrow with the cutter bar;

2. Stubble spread by raking but not mowed;

3. Stubble burned (fall burn); and

4. No further treatment (control)

These four treatments will be arranged in a randomized block design with three replicates per alternate crop, which will then be direct seeded as part of the entire 5-A strip.

Cunningham Agronomy Farm Project No. 3—Crop Rotations as Alternatives to Burning for Root Disease Management on Wheat.

In addition to easier planting, wheat after wheat (no rotation crop) in the higher-precipitation areas and under irrigation typically yields 10-15 bu/A more where stubble is burned prior to planting than where left standing (see Appendix A). The lower yields with stubble left standing is due primarily to a complex of root diseases caused by soilborne fungal pathogens. The root diseases are take-all, caused by *Gaeummanomyces graminis* var. *tritici*, Rhizoctonia root rot, caused by *Rhizoctonia solani* AG8 and *R. oryzae*, Pythium root rot caused by several *Pythium* species, and Fusarium root and crown rot, cause by *Fusarium psuedograminearum* and *F. culmorum*. These pathogens are concentrated in the top 4-6 inches of soil, and the pathogens responsible for take-all and Fusarium root and crown rot also live in the bases (crowns) of wheat plants left as stubble in the field. In addition, take-all and Rhizoctonia and Pythium root rots each are favored by cool moist soil conditions typical of the top 4-6 inches of soil under direct seed conditions for both late-planted winter wheat and early-planted spring wheat. All research shows to date at the burning does not kill pathogens in the soil, and that the take-all and Fusarium pathogens in tiller bases survive to within ¼ inch of the charred ends of burned stubble. For those root diseases favored by cool moist soil conditions, leaving straw on the soil surface provides these favorable environmental conditions, whereas their activity is greatly limited or virtually arrested by the warmer drier conditions of the top few inches of soil made bare black by burning. Since these pathogens are ubiquitous in the wheat-growing region of eastern Washington and adjacent Idaho and Oregon, being favored by continued presence of wheat and barley host plants, the increased yield response can also be expected and demonstrated in virtually any field with heavy straw residues.

This project will examine the only practical method for root disease management without stubble burning—crop rotation. Two other sources of funds will become available during 2002 that will look at a wide range of rotation effects, including on root diseases, in direct seed systems. These are a project funded by the federal Solutions to Environmental and Economic Problems (STEEP) and a project funded by the Washington Wheat Commission (funds start July 1, 2002). Neither of these source of funding is adequate for the kind of documentation needed and possible in this novel direct seed cropping systems project. We will focus this proposed DOE-funded part of the project on documenting the specific benefits of the six different rotations (described above for CAF No. 2) on the complex of root pathogens and the diseases they cause using a new DNA test together with visual assessments of the root diseases.

For the DOE-funded portion of this work, we will use state-of-the-art DNA tests to quantify the amount of pathogen inoculum at all 25 georeferenced sites within each rotation a) prior to planting spring wheat in 2002, the first wheat crop following the six alternate crops, and b) at these same 25 georeferenced sites after harvest of the spring wheat but before planting winter wheat in the fall of 2002, the second wheat crop following the six alternative crops (see Fig 1). The first samples were taken in April and are dried and stored in anticipation of funding. There is no loss of sample quality for the DNA tests during storage. In addition, we will obtain plant samples of both the 2002 spring wheat crop and the 2002/2003 winter wheat crop for assessments of the respective root diseases at predetermined times during the growing season. This site represents an unprecedented opportunity to document and compare effects on root pathogens of rotations that use continuous cereals (winter wheat/winter or spring barley/spring wheat) versus rotations that use a broadleaf break crop between the winter and spring wheat.

Lind Research Station Project—Documentation of Wheat Straw Management and Rotation Alternatives to on Root Pathogen Populations Under Irrigation.

This project was established in the fall of 2001 with partial funding from the U.S. EPA and involves approximately 10 A devoted to two rotations and three methods of wheat straw management. One rotation/straw management treatment is intended to represent a current practice in parts of the low-precipitation areas of continuous winter wheat irrigated from deep wells with straw burned and the fields moldboard plowed after each harvest in preparation for planting the next crop of winter wheat. The alternative systems uses a 3-year rotation of winter wheat/spring barley/winter Canola as the main block with three straw management treatments as subblocks. The three straw management treatments are no treatment (residue left as spread at harvest), spring barley or winter wheat straw mechanically removed by baling, and straw burned. In each of these straw management treatments, spring barley is the crop planted where the treatments were applied to winter wheat straw, and winter Canola is planted where the treatments were applied to spring barley stubble. No residue management treatments are imposed on the winter Canola stubble before planting winter wheat.

Like the CAF project No. 3, this site offers an excellent opportunity to document the effects of rotations and alternative straw management practices on populations of soilborne pathogens and severity of root diseases. Our extensive experience with root diseases of winter wheat under irrigation, would predict that take-all and Fusarium root and crown rot caused by *F. pseudograminearum* will be the main diseases likely to build up with intensive wheat but whether either can be controlled by this 3-year rotation with two host-crops (wheat and barley) is still unknown. We already see evidence of increased risk of white mold caused by *Sclerotinia sclerotiorum* on the winter Canola planted into standing stubble of spring barley but not in the burned plots, possibly because of the favorable habitat provided for this soil-surface pathogen of broadleaf crops.

B. Work Plan

Establishment of the Straw Management Treatments.

All harvesting on the CAF in preparation for or as part of establishement of the straw management treatments will use a new (2002) John Deere Model 9750STS equipped with the latest technology for chopping straw and spreading chaff. John Deere Co. has already agreed to make a demo combine available for 7 consecutive days during the 2002 harvest at half the normal $160/hour cylinder time. The blades provided with the straw chopper will be further sharpened and maintained razor sharp during use. The heavy harrow equipped with a cutter bar will be leased from Combs of Spokane. This is a 60-foot-wide implement with a hydraulically driven cutter bar. The same harrow with the cutter bar raised and turned off will be used for the 3rd treatment. Each treatment within each replicate will be 60 feet wide, the width of the heavy harrow, twice the width of the 30-foot combine header, and four times the 15-foot width of the Great Plains drill available for planting the winter wheat. Because of the contour of the site available for CAF No. 1, not all straw-management strips will be the same length, but each will transect north- and south-facing slopes. The drill is equipped with the Great Plains Turbo Coulters™ for fertilizer injection in the front and double disk openers for seed placement at the rear, both on 10-inch spacing and aligned so that fertilizer is placed within each seed row below the seed.

The entire sites for CAF No. 1, 2 and 3 are already marked by GPS-on a nonaligned grid with roughly 100 yds between the GPS-referenced points. However, soil samples to 5-foot depths must still be taken for characterization of soil types and soil depth on the site dedicated to CAF No.1. These points will be used as the sites for all sampling and mapping for soil characteristics and crop growth, development, and yield. Because of the different aspects and slopes within each treated area, data can be obtained and analyzed separately as appropriate from the drier and wetter sites all within the same strips.

The site available for the CAF No. 1 study has been in a 2-year winter wheat/spring wheat rotation for several years, and has been direct seeded for the past three years. A soft white spring wheat (cv Zak) was planted in the spring of 2002, fertilized for a yield potential of 75 bu/A, and will provide the stubble and straw residue for the treatments prior to planting winter wheat cv. Madsen in the fall of 2002.

Establishment of Fumigated and Burn Plots

Small plots will be fumigated with methyl bromide with and without burning in each of the replicated straw management strips in CAF No. 1 to estimate the full growth potential of winter wheat and the impact of straw residue on wheat growth in the respective methods of straw management. Methyl bromide is applied under clear plastic tarp at a rate equivalent to 400 lbs/A. Methyl bromide fumigation has been used routinely in our program for more than 35 years as a tool to estimate the full production capability of wheat with available water and fertility, growing season, and variety in a given field and season (see Appendix A for examples). Yields in control plots expressed as a percentage of yield in the corresponding fumigated plots will serve as a measure of the relative root disease pressure on wheat in response to the different straw management treatments. The paired plots will be located to the extent possible over deep soil near a toeslope so as to maximize the yield potential and hence the fumigation response.

Monitoring of seed zone temperatures and moisture in response to straw management treatments

Soil moisture and temperature will be monitored over time and space within one replicate of each of the four straw management treatments in CAF No. 1. TDR will be used to monitor seed zone moisture and thermal couples will be used to monitor temperature. The basic system for monitoring and downloading data automatically is already in place on the Cunningham Agronomy Farm. These data, in turn, will be used in a related study on modeling soil moisture and temperature needs for germination of several alternative crops as well as wheat.

Seed zone moisture and temperature will also likely be different within the old (relic) stubble rows compared to soil in the space between stubble rows. Thus, in the case of the spring wheat stubble destined for winter wheat, we will actually monitor seed zone moisture, temperature and freeze/thaw cycles both within and between representative relic stubble rows. This aspect of the work will be the most intense combination of in-situ measurements. Thermocouples, TDR probes, infiltrometers, frost tubes and direct observations or gravimetric measurments will be used on a) freezing, thawing, and snow distribution; and b) near-surface as well as seed-zone water potentials, temperatures, and heat dissipation over time for the representative sites.

Use of the Haun method to compare growth and development of wheat and barley in response to straw management treatments

We will used the Haun method to document early growth and developmental responses of winter wheat to the different spring wheat straw management treatments (CAF No. 1), winter barley to the different winter wheat straw management treatments in CAF No. 2), and of spring wheat to the alternative crops with no special method of residue management (CAF No. 3). This method determines both the total number of tillers formed on wheat or barley plants and also which tillers are formed or fail to form on representative plants from any given treatment. Tillers form on the mainstem of wheat and barley in an orderly sequence on a schedule based on accumulated growing degree-days from the day of planting (Fig 2). This labor-intensive but highly instructive measurement requires the examination of populations of representative plants for the presence or absence of the respective tillers programmed to form if the plant is perfectly healthy with no stress. The coleoptile tiller (T-O) forms only under the most ideal of growing conditions. This T-O is followed, in sequence, by tillers 1, 2, 3, etc., formed in the axils of leaf 1, 2, 3, etc. on the mainstem. Failure of any tiller to form on schedule represents a permanent limitation to yield, since once skipped during plant development, only the next and subsequent tillers in the sequence will form but not those that failed to form when it was their turn. A high percentage of plants missing tillers 1 and 2, for example, would indicate stressful conditions precisely during the times these tillers were scheduled to form based on accumulated growing degree days. Without compensatory growth in the form of larger heads or plumper grain, grain, yield is impacted accordingly.

Use of DNA tests to quantify pathogen inoculum in soils

A quantitative test applied to DNA extracted from soil and available in Australia will be used for *R. solani* AG8, *Fusarium pseudograminearum*, *F. culmorum*, and *G. graminis* var. *tritici* for both CAF No. 3 and at Lind. This new test represents a major breakthrough for root diseases prediction and management. In addition, we will determine the incidence and severity of the different root diseases on plant samples collected at appropriate times during crop growth. Pythium and Rhizoctonia root rot show up early in plant development, including before and during the tillering stage. To evaluate the amount of these root diseases in CAF No. 3, spring wheat plants from the

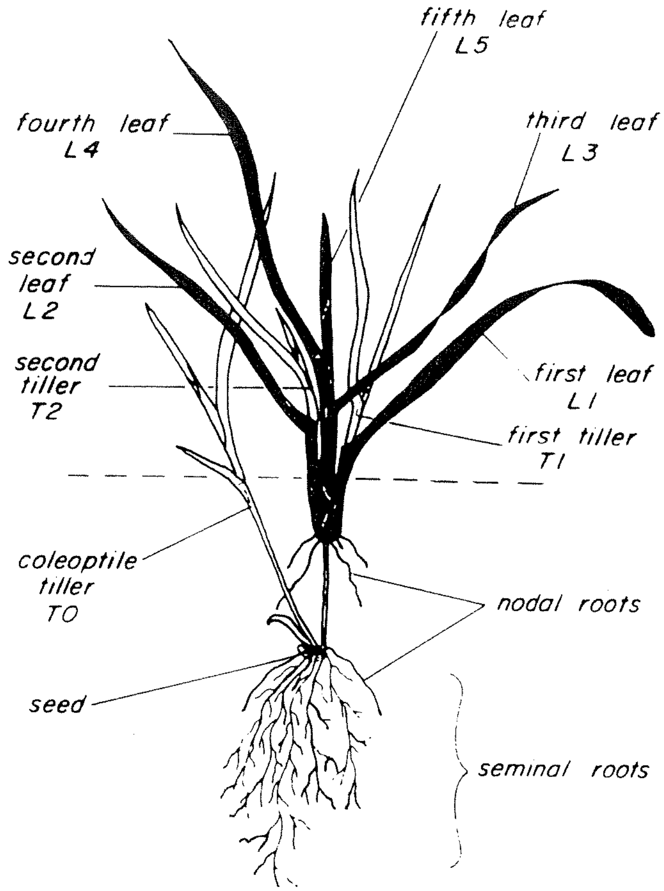


Fig. 2. Diagrammatic illustration of a healthy wheat plant, showing the order of leaves and tillers from which Haun determinations are made for comparative growth and development measurements. Drawing from B. Klepper, R. W. Rickman, and R. K. Belford, 1983. Leaf and Tiller Identification on Wheat Plants. Crop Science 23:1002-1004.

different crop rotations will be collected at the 4- to 5-leaf stage (2-tiller stage) at each of the geo-referenced sites in 2003 and washed roots will be processed using another modern innovation—digital analysis (WinRhizo)—for root length, root diameters, and root surface area. Take all and Fusarium root and crown rot appear on plants during and after heading. To evaluate the incidence and severity of these diseases in both CAF No. 3 and the Lind site, plants in the heading stage will be collected at each of the geo-referenced sites in 2002 and scored for incidence and severity of take-all and Fusarium crown rot and for determination of the relative frequencies of *F. pseudograminearum* and *F. culmorum*.

C. Project Schedule

June, 2002	Recruit and hire skilled technician for 6-month (July 1-Dec 31, 2002) full time work.
July	Assess severity of take-all and Fusarium root and crown rot on spring wheat for different rotations in CAF No. 3 and Lind.
	Layout plots for straw treatments in CAF No. 1
August	Harvest winter wheat in CAF No. 2 and layout plots for straw treatments
	Harvest spring wheat in CAF No. 1 and impose straw management treatments with heavy harrow with and without cutter bar.
	Begin grid sampling of CAF No. 1 based on georeferenced sites using GPS for soil characteristics and residual nitrogen and water
September	Complete grid sampling and soil mapping of CAF No. 1
	Burn small plots for both CAF No. 1 and 2
	Sample CAF No. 3 and Lind plots for DNA analysis of root pathogens
October	Fumigate plots in the 4 straw treatment x 4 reps using methyl bromide
	Plant and fertilize winter wheat over straw treatments in CAF No. 1; alternative crops into winter wheat stubble in CAF No. 2, and winter wheat after spring wheat in the six rotations of CAF No. 3
	Install thermocouples, TDR probes, infiltrometers, and frost tubes; begin monitoring seed zone temperature and moisture
November	Make stand counts of winter crops in both CAF No. 1 and 2
	Winterize field equipment.
December	Develop maps and databases of soilborne pathogen populations based on DNA tests and root and crown disease ratings based on plant assessments for CAF No. 3 and Lind.
January, 2003	Continue work on development of maps and processing of data; develop databases

February Begin recruitment of timeslip help for spring work

March/April Sample CAF No. 3 for DNA analysis and root scans using WINRHIZO

April/May Sample CAF No. 1 and 2 for Haun ratings of plants in tillering stage

June Hold field days for farmers to view the work.

D. Deliverables

1. Clear indication if, when straw is chopped into short lengths and spread the full width of the header, any additional treatment is necessary, e.g., stubble cut shorter and/or spread straw with a heavy harrow, to assure stand establishment and vigorous plant growth using a one-pass direct-seed system of planting and fertilizing winter wheat into spring wheat stubble.

Since the winter wheat can be direct seeded into sites with the four alternative straw management treatments (CAF No. 1) but will not yet be harvested within the June 1, 2002-June 1, 2003 timeframe of this project, we will use differences in stand establishment and wheat plant growth to assess the need, if any, for special straw management during or after harvest. The Haun method of determining early plant growth and development is sensitive enough to pick up these differences. Likewise if there are any landscape effects of these treatments, our method of grid sampling based on georeference sites will show these differences. A given method of straw management may work on south slopes but not on north slopes, as an example. We will also document differences seed zone temperature and moisture, water infiltration, stand establishment and tillering (based on the Haun ratings) for burned and nonburned plots, with and without fumigation, as appropriate, to explain any differences in stand establishment and or plant growth and effects on root diseases of a given straw management treatment.

We will also document the costs of the respective straw management treatments in additional time required either during harvest or after harvest on a per-acre basis to impose the different straw management treatments compared to normal harvest but aggressive straw chopping and chaff spreading.

2. Further clarification of the need for or value of shortening and chopping the stubble to short lengths, but done with winter wheat stubble in preparation for fall seeding a crop other that winter wheat.

This study will address the greatest challenge of all to direct seeding—planting in the fall into fresh winter wheat stubble. In addition to the planting challenges, growers that attempt this by planting winter wheat into winter wheat stubble find their fields quickly overrun with cheat grass and jointed goat grass. The Lind project seeks alternatives to the unsustainable practice adopted by some growers for continuous winter wheat using irrigation—burn and then moldboard plow. Most growers without irrigation have long since abandoned continuous winter wheat but there is great interest and need for alternative fall-sown crops for direct seeding into the heavy stubble of winter wheat. This project includes three alternative fall-sown crops, one of which is a cereal (winter barley) with potential to create the same weed problems encountered with continuous winter wheat.

3. First maps for any site in the United States of pathogen load based on the precision of a DNA test.

Most growers are not aware that the yield response of winter wheat to stubble burning is due to mitigation of damage caused by root pathogens. Even among experts in root disease research, it is difficult to understand and document the dynamics of the different root pathogens in response to different rotations or residue management treatments since methods for estimating the pathogen load in soil have been too crude or nonexistent. That situation is now changing because of the new tools of molecular biology used to measure the amount of specific pathogens based on their unique DNA. We have worked with the Australian group to verify the validity of their tests for eastern Washington soils and therefore have confidence that the data will be highly useful and revealing practically and scientifically. In Australia where the test was developed and patented, farmers can now obtain information on the pathogen loads in soil before planting wheat much as they use soil tests to determine the nitrogen supply before deciding or rates of fertilization. We will complement the results of the DNA tests with visual ratings of both young and adult plants for root disease severity to fully reveal the effects, if any, of the rotations and straw management treatments in CAF No. 3 and the Lind project. .

4. Maps of crop growth on a landscape basis, using aerial and infrared photography and GPS referencing, and maps of pathogen concentrations and distribution by previous crop (rotation) and straw management treatment, all based on georeferencing.

We already have maps of historic yields, grain protein, and aboveground biomass production for the 92-A site now used for the crop rotation study referred to in this proposal as CAF No. 2 and 3. We expect to visualize treatment effects based on previous crop and straw management treatments for all three projects using one or more of the measurement methods and mapping techniques.

5. Field days on the CAF and Lind Station in June, 2003, when and where the results of these projects can be shared directly and visually with growers.

MANAGEMENT PROPOSAL

Title: Straw Management and Crop Rotation Alternatives to Burning Wheat Stubble

Principal Investigator: R. James Cook, Department of Plant Pathology, Washington State University.

Co-Principal Investigators: **David Huggins, Soil Scientist, and Timothy Paulitz, Plant Pathologist, U.S. Department of Agriculture, Agricultural Research Service, Pullman, WA.**

Collaborator: **William Schillinger, Dryland Research Agronomist, Washington State University**

A. **Project Management**

1. **Project Team Structural/Internal Controls.** All work will be done by employees of Washington State University and the U.S Department of Agriculture with adjunct appointments at WSU. An organizational chart and lines of authority are provided on the following page.

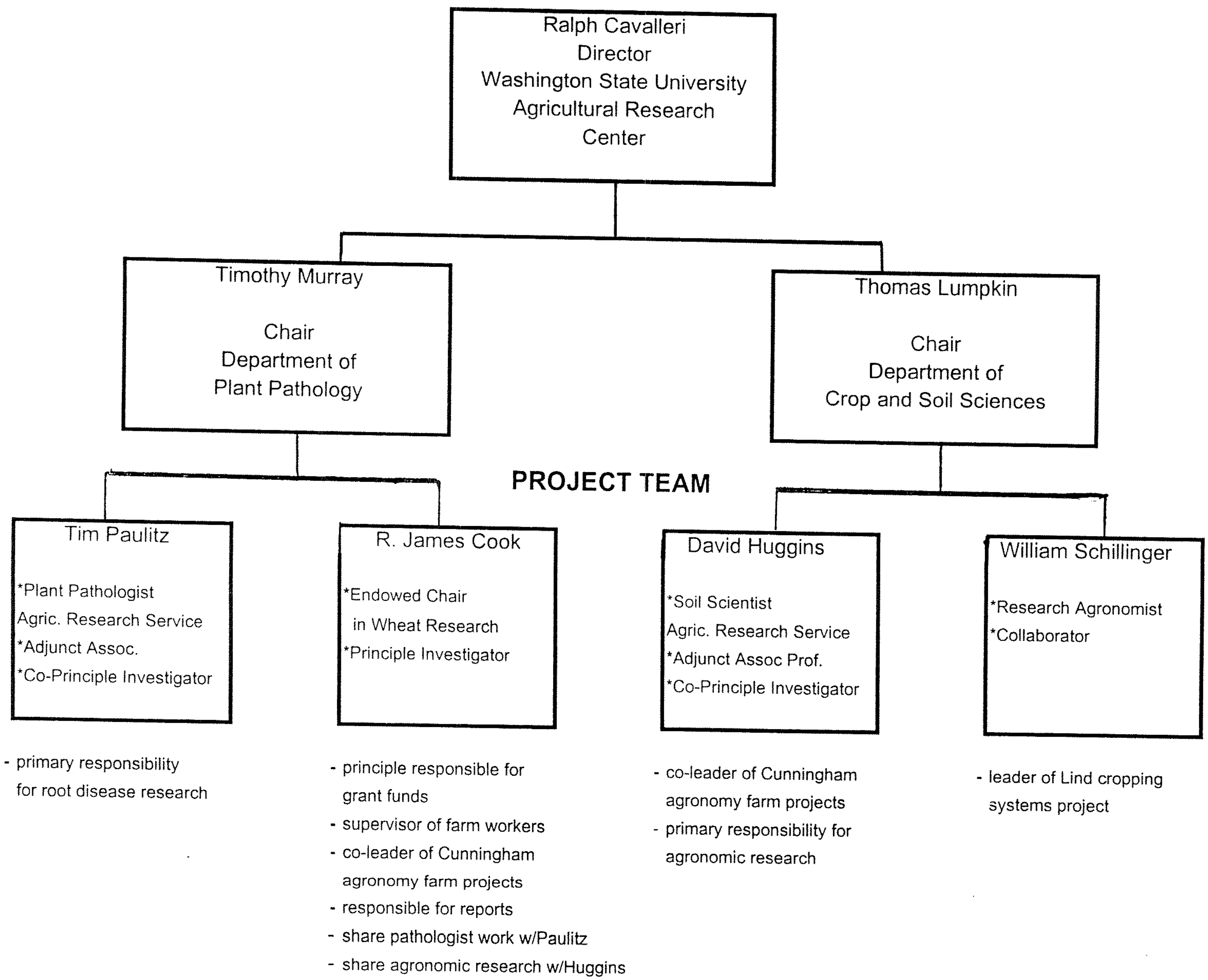
2. **Staff Qualifications/Experience**

   All farm work, including planting, spraying for weed control, and harvesting, will be done by Ryan Davis, WSU Ag Tech II. Ryan grew up on a farm in eastern Washington and had done all farming on the Cunningham Agronomy Farm since the fall of 1999. He is had a BSc. degree in range management from WSU, and is currently working towards an MSc. degree in Plant Pathology from WSU.

B. **Experience of Applicant**

1. **Experience related to the research proposed.**—R. James Cook, as principal investigator, has been at WSU for 37 years. From 1965-1998, he developed and was responsible for the USDA-ARS research program on root diseases of wheat and barley. He is currently serving as Endowed Chair in Wheat Research, a position created by a $1.5 million endowment from the Washington Wheat Commission to do cropping systems research. He and Dr. David Huggins, USDA-ARS Soil Scientist, share responsibilities for management of the WSU Cunningham Agronomy Farm. In addition, Cook has direct seeding research work carried out by WSU Ag Tech III Ron Sloot in cooperation with growers at Bickleton, Colfax, and sites near Pullman.

MANAGEMENT PROPOSAL



Dave Huggins, USDA-ARS Soil Scientist and Co-Principal Investigator on this project, has 10 years experience as a soil scientist in cropping systems research, including soil fertility needs in direct-seed systems, crop residue management, crop modeling, grain protein management, and conservation farming. He is also responsible for management of the Palouse Conservation Field Station near Pullman.

Timothy Paulitz, USDA-ARS Research Plant Pathologist, and Co-principal investigator has 10 years experience working with a wide range of root diseases and soilborne pathogens of both cereals and broadleaf crops. His assignment as a federal pathologist stationed at WSU is to conduct research root diseases primarily of cereal crops and the develop methods for their control.

William Schillinger, Dryland Research Agronomist with Washington State University and manager of the WSU Experiment Station at Lind is leader of the irrigated project at Lind and therefore a collaborator on this proposed project. He has extensive experience in soil, fertility, water, and crop residue management in the low-precipitation zones of the PNW, including under irrigation.

2. **Relevant qualifications**—Each of the investigators have a history of working together and in conducting research under field conditions on ways to both achieve high crop yields and protect air, water, and soil quality for the PNW using direct seed systems.

3. **List of contracts.**—Current and pending funding of the Principal Investigator is attached.

C. References

Mr. Tom Mick, Administrator, Washington Wheat Commission, Spokane, WA
Phone 509/456-2481

Mr. John Aeschliman, JEA Farms, Colfax, WA
Phone 509/397-3118

Mr. Steve Matsen, Grower, Bickleton, WA
Phone 509/896-5231

Mr. Karl Kupers, President, Pacific Northwest Direct Seed Association
Harrington, WA
Phone 509/721-0374

CURRENT AND PENDING SUPPORT

Instructions:

1. Record information for active and pending projects.
2. All current efforts to which project director(s) and other senior personnel have committed a portion of their time must be listed, whether or not salary for the person involved is included in the budgets of the various projects.
3. Provide analogous information for all proposed work which is being considered by, or which will be submitted in the near future to, other possible sponsors.

NAME (List/PD #1 first)	SUPPORTING AGENCY AND AGENCY ACTIVE PROPOSAL NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
	Active:				
Cook, R.J.	Endowed Chair	52,000	7/1-6/30	50%	Endowed Wheat Research
	WA Barley Commission	13,200	7/1-6/30	5%	Rhizoctonia root rot in direct seed systems
	USDA-ARS	33,000	10/1-9/30	5%	Population biology and genetic control of wheat and barley root pathogens
	Syngenta	5,000	unlimited gift grant		In support of seed treatment research
	WA Wheat Foundation	7,000	One-time equipment purchase		Build sprayer for Cunningham Farm
	STEEP	132,500	9/30/02-04	10%	Rotation effects in direct seed system
	WA Wheat Commission	15,000	7/1/02-6/30/03	5%	Root and crown diseases caused by Fusarium and Rhizoctonia species
	Pending:				

COST PROPOSAL

Straw Management and Crop Rotation Alternatives to Burning Wheat Stubble

Principal Investigator: R. James Cook, Department of Plant Pathology, Washington State University.

Co-Principal Investigators: David Huggins, Soil Scientist, and Timothy Paulitz, Plant Pathologist, U.S. Department of Agriculture, Agricultural Research Service, Pullman, WA.

Collaborator: William Schillinger, Dryland Research Agronomist, Washington State University

Budget (June 1, 2002-June 1, 2003)

Salaries (0.25 FTE Ag Tech II/III)[1]	$8,275
Benefits @ 27%	2,234
Timeslip	
6-month full-time temp[2] @ $14/hr	14,560
Benefits @ 16%	2,330
4-month, full-time temp, students[3] @ $8/hr	5,550
Benefits @ 1.5%	83
Total salaries, wages, and benefits	33,032
Supplies and Services	
Combine lease @$80/hr	800
Heavy Harrow lease + transport	400
DNA soil tests @ $35/sample[4]	9,000
Fuel and machinery maintenance	1,000
Sample bags, shipping, misc.	1,000
Aerial photography	600
Equipment	
Compaq IPAQ[5]	800
Pickup truck, lease from WSU motor pool	1,000
Total Direct Costs	**$47,632**
Indirect costs @ 46.8%	22,292
Total Costs	**$69,924**

[1]Salary includes funds for up to 30 hours of overtime, necessary to complete the farm work on a timely basis.

[2]Hourly wage set high enough to attract a skilled farm worker and technician, preferably with a BS degree in agronomy, since the job is only temporary yet without necessary skills, the extra work load will fall on the lead technician Ryan Davis.

[3]Average hourly wage for part-time student help, in competition with work study program on the WSU campus. We intend to hire the equivalent of 1 FTE, which will mean possibly three students for April and May.

[4]Soils for the DNA test are sent to Adelaide, Australia, where the charge is $A65 per sample as charged agribusinesses and farmers in Australia. With the favorable exchange rate currently at $0.52-0.55, the price is estimated at about $35 per sample. Even if we could do these same tests in house, which we cannot because of the proprietary nature of the test, our costs are more affordable than acquiring the equipment and personnel to do these tests.

[5]A hand held computer with software that is connected to the GPS unit for use in the field.

Appendix A

The three experiments presented in brief below are examples of many experiments completed over the past 20 years demonstrating the role of root disease control in the response of wheat and a wheat disease to burning. Each experiment was in a grower's field and replicated four times. Data of R. James Cook

Table 1. Yield responses of winter wheat to crop rotation, burning, and soil fumigation. This experiment was done near Rockford, WA with winter wheat seeded by the grower using a no-till drill.

Previous Crop	Soil left natural	Soil fumigated
Bu/A	Bu/A	
Spring wheat		
Stubble left natural	67.6	76.1*
Stubble burned	87.5	89.2
Lentils	92.2	93.7

*Significantly different from natural soil treatment at P= 0.05

Table 2. Yield responses of winter wheat following winter wheat to burn and burn with fresh straw returned to cover the soil the burned soil surface, with and without fumigation with methyl bromide near Colfax.

Treatment	Yield (Bu/A)
Stubble burned	94.0
Stubble burned; soil fumigated	98.5
Stubble burned; straw returned	73.1*
Burned/returned; fumigated	95.5

* Significantly at P= 0.05

Table 3. Influence of burn, burn with fresh straw returned to cover the burned soil surface, and methyl bromide fumigation on incidence of the wheat root disease, take-all, caused by the soilborne fungal pathogen *Gaeumannomyces graminis* var. *tritici*, common throughout the Inland Northwest. Experiment conducted near Pullman

Treatment	Take-all (% diseased plants)
Stubble left natural (no burn)	30
Stubble burned	18
Stubble burned/fresh straw returned	40
Stubble left natural/fumigated	12